

Q. What is the circumference of the earth ? I mean, how many miles is it round ?

A. 25,058 miles.

Q. Was it ever sailed round ?

A. Frequently ; first by Magellan a Spaniard ; afterwards by Sir Francis Drake, our own countryman ; and, in later times by Commodore Byron, Captains Cook, Furneaux, Carteret, Wallis, and others.

Q. What discoveries did these circumnavigators make ?

A. The two first made very few ; but the last have found that the great South-sea, in certain latitudes, is covered with an infinite number of islands, and one of them in particular, called New South Wales, so large, that it almost deserves the name of a continent.

Q. I think I have heard of a remarkable circumstance that occurs according as a ship directs her course east or west in sailing round the world. Is there not such a one ?

A. There certainly is, and it is this. If a ship sets out from any port, and sails round the earth eastward to the same port again, let her take what time she will to do it in, the people in that ship, in reckoning their time, will gain one complete day at their return, or count one day more than

than those who reside at the same port; because by going contrary to the sun's diurnal motion, and being forwarder every evening than they were in the morning, their horizon will get so much the sooner above the setting sun than if they had kept for a whole day at any particular place. And thus, by cutting off a part proportionable to their own motion, from the length of every day, they will gain a complete day of that sort at their return; without gaining one moment of absolute time more than is elapsed, during their course, to the people at the port.

If, on the other hand, they sail westward, they will reckon one day less than the people do who reside at the said port, because by gradually following the apparent diurnal motion of the sun, they will keep him each particular day so much longer above the horizon, as answers to that day's course; and, by that means, they cut off a whole day in reckoning, at their return, without losing one moment of absolute time.

Hence, if two ships should set out at the same time from any port, and sail round the globe, one eastward and the other westward, so as to meet at the same port on any day whatever, they will differ two days in reckoning their time, at their return. If they sail twice round the earth, they will

will differ four days; if they fail thrice, they will differ six days; if four times, eight days, &c.

OF THE WIND.

Q. I should like to have a more particular account of the wind than any I have yet received: will you be pleased to give it me?

A. I will endeavour to do so.

Q. I shall be much obliged to you.

A. You know then, as I formerly told you, that wind is chiefly occasioned by a rarefaction of the air; for when the air is rarefied, it naturally ascends into the higher regions; and the circumjacent air, which is thicker and heavier, immediately rushes in to supply its place, and fill up the vacancy. This motion of the air we call wind, and we give it the name of a breeze, a gale, or storm, according to the quickness or velocity of its motion.

Q. All this I perfectly understand, and very well remember. But I wish you would be a little more particular. Are there not certain winds, called tropical winds, which blow almost always from the same point of the compass?

A. There

A. There are, and they are of three kinds.

1. The *general trade winds*, which extend to near thirty degrees of latitude on each side of the equator, in the Atlantic, Ethiopic, and Pacific oceans. On the north side of the equator, they blow from north-east, on the south side from south-east, and near the equator from almost due east.

2. The *monsoons*, or shifting trade winds, which blow six months in one direction, and the other six months in an opposite direction. These are mostly in the Indian or Eastern ocean, and do not reach above two hundred leagues from the land. Their change is at the vernal and autumnal equinox, and it is accompanied with terrible storms of thunder, lightning, and rain.

3. *The land and sea breezes*, which are periodical winds, and blow from the land from night to about mid-day, and from the sea from about noon to mid-night. These winds do not extend above two or three leagues from the shore.

Beyond the latitude of thirty degrees, north and south, the winds, as we daily perceive in Great Britain, are more variable, though it may be observed in general, that the tendency of the wind is from a colder region to that which is hotter.

OF THE TIDES.

Q. What have you to observe of the tides besides what you formerly mentioned?

A. It must first be observed, that the sun attracts the earth, as well as the moon does; but he attracts it, however, with much less force, on account of his infinitely greater distance.

Q. When have we the highest tides?

A. At the new and full moon, and the tides then are called spring tides; for at these times the actions both of the sun and moon are united, and draw in the same straight line, and consequently the sea must be more elevated. At the conjunction, that is, the new moon, when the sun and moon are on the same side of the earth, they both conspire to raise the waters in the zenith, and consequently in the nadir; and at the opposition, or full moon, when the earth is between the sun and moon, while one occasions high water in the zenith and nadir, the other does the same.

Q. When do the lowest tides happen?

A. The lowest tides, or (as they are usually called) the neap tides, happen about the first and last quarters of the moon; for then the influence

of the sun and moon counteract each other : the sun raises the waters where the moon depresses them, and depresses where the moon raises them ; so that the tides are only occasioned by the difference, by which the action of the moon, which is nearest us, prevails over that of the sun.

Q. Do these things happen regularly ?

A. They would do so, were the whole surface of the earth covered with water, but as there is a multitude of islands and continents, which interrupt the natural course of the water, a variety of appearances are to be met with in different places, which cannot be explained without regarding the situation of shores, straits, and other objects, which have a share in producing them.

Q. Are there not various currents in the sea ?

A. Yes; there is a current between Florida and the Bahama islands, which always runs from north to south. A current runs constantly from the Atlantic, through the straits of Gibraltar into the Mediterranean. A current sets out of the Baltic sea, through the Sound or strait between Sweden and Denmark, in the British ocean, so that there are no tides in the Baltic.

Q. But if a current constantly runs from the Atlantic into the Mediterranean, is it not strange that the waters of the sea do not increase ?

A. No ;

A. No: the water extracted from it in vapours is more than sufficient to counterbalance the influx.

Q. How does this appear?

A. It has been found by calculation, that in a summer's day, there may be raised, in vapours, from the Mediterranean 5280 millions of tons of water, yet this sea receives not from all its nine great rivers above 1827 millions of tons per day, which is but one third of what is exhausted in vapours; so that, were it not for the influx from the Atlantic, the Mediterranean would soon be rendered dry.

Q. How high do the tides ever rise?

A. About small islands, and the headlands in the middle of the ocean, the tides rise very little; but in some bays, and about the mouths of rivers, they rise from 12 to 50 feet.

Q. Are the tides always highest precisely at the time of the new and full moons?

A. No; they are generally highest about three tides after.

Q. Are the same tides (viz. spring and neap) of the same height in the same place all the year round?

A. No; for as I have already said, the earth is somewhat nearer the sun in winter than it is in summer; and therefore the greatest equinoctial tides

tides are observed to happen some time before the vernal equinox, and a little after the autumnal one.

ELECTRICITY.

Q. Whence comes the word electricity?

A. From the Greek word *λέιπτρον*, signifying amber, which was the first substance that was observed to have the property of attracting straws and other light bodies; for this was the simple origin of a science that is now arrived at very great perfection.

Q. Is not the word electricity commonly taken in a more extended sense?

A. It is commonly understood to mean the electrical matter, or the art of putting that matter in motion, or calling it into motion.

Q. What is the electrical matter?

A. It is a subtle fire that pervades all nature, and produces the most surprizing effects.

Q. What are the principal of these effects?

A. Thunder and lightning is undoubtedly one of them; earthquakes are probably, at least in some

some measure, another ; and it is even supposed by some philosophers, that the *Aurora Borealis*, or northern lights, are owing to the same cause.

Q. How does it appear, that thunder and lightning are owing to electricity ?

A. Dr. Franklin has proved, by a variety of experiments, that the lightning of electricity and the lightning that flashes from the clouds in a thunder storm, are exactly of the same kind, and operate in the same manner.

Q. I should be glad to hear the particular points, in which these two kinds of lightning agree, and produce the same or similar effects.

A. You are right in saying similar ; for though they are certainly the same in kind, they are not always the same in degree : the works of men can never equal the operations of nature.

Q. In what respects, then, do they agree ?

A. I shall inform you almost in the doctor's own words ; after observing, that electricians have the art of making a machine, by which they can draw fire from a variety of bodies, and even accumulate, or heap it together in such quantities, that when it is discharged, or let off, it will make a report like a pistol, and even kill animals.

Q. I should like to see such a machine ?

A. You may see it at the shop of any maker of

of mathematical instruments, and such are to be found in every capital town in the kingdom. But to describe to you a machine, which you could not make, would be not only dry and uninteresting, but almost unintelligible. You must, therefore, at present, take the thing for granted.

Q. Very well; proceed, if you please, with the particulars, in which these two kinds of lightning agree.

A. Here, then, they follow:

1. Flashes of lightning, says the doctor, are generally seen crooked, and waving in the air. The same, adds he, is the electric spark always, when it is drawn from an irregular body at some distance.

2. Lightning strikes the highest and most pointed objects in its way preferable to others, as high hills and trees, towers, spires, masts of ships, points of spears, &c. In like manner, all pointed conductors* receive or throw off the electric fluid more readily than those that are terminated by flat surfaces.

* Conductor is a term used by electricians for denoting any thing that conducts the electric fire from one body to another.

3. Lightning is observed to take the readiest and best conductor. So does electricity in the discharge of the Leyden phial.*

For this reason the doctor supposes, that it would be safer, during a thunder storm, to have one's cloaths wet than dry, as the lightning might then, in a great measure, be transmitted to the ground, by the water on the outside of the body. It is found, he says, that a wet rat cannot be killed by the explosion of the electrical bottle, but that a dry rat may.

4. Lightning burns: so does electricity. Dr. Franklin says, that he could kindle with it hard dry rosin, spirits unwarmed, and even wood.

5. Lightning sometimes dissolves metals: so does electricity.

6. Lightning rends some bodies: the same does electricity. Dr. Franklin observes, that the electric spark would strike a hole through a quire of paper.

7. Lightning has often been known to strike people blind. And a pigeon after a violent shock of electricity, by which the doctor intended to

* A glass that contains an accumulation of electric matter.

have killed it, was observed to have been struck blind likewise.

8. Lightning destroys animal life. Animals have likewise been killed by the shock of electricity. The largest animals, which Dr. Franklin and his friends had been able to kill, were a hen, and a turkey which weighed about ten pounds.

To demonstrate, in the clearest manner possible, the sameness of electrical fire with the matter of lightning, Dr. Franklin, astonishing as it must have appeared, contrived actually to bring lightning from the heavens, by means of an electrical kite, which he raised when a storm of thunder was perceived to be coming on.

This kite had a pointed wire fixed upon it, by which it drew the lightning from the clouds. The lightning descended along the hempen string that held the kite, and was received by a key tied to the extremity of it; that part of the string which the doctor had in hand, being of silk,* that the electric fire might stop at the key, and not reach his body.

He found, that the string would conduct electricity even when nearly dry, but that, when it

* Some bodies conduct the electric fire, and some do not conduct it. Silk is of the latter kind.

was wet, it would conduct it quite freely ; so that it would stream out plentifully from the key, at the approach of a person's finger.

At this key he charged phials, and from electric fire thus obtained, he kindled spirits, and performed all the common electrical experiments.

Q. Was not this discovery, of the sameness of lightning and electricity, applied by Dr. Franklin to a most useful purpose ?

A. It certainly was, namely, to the securing buildings from the dreadful effects of lightning in a thunder storm ; for as to the thunder itself, or the sound or noise we hear, it is perfectly harmless ; it is the lightning alone that does the mischief.

Q. How did he effect this ?

A. Only by fixing a pointed iron rod higher than any part of the building, and joining to the lower end of it a wire, which communicated with the earth, or rather the nearest water. This rod the lightning was sure to seize upon preferable to any other part of the building, and descended along it and the wire till it reached the earth, where it was instantly dissipated, without doing any harm.

Q. Ought not all public buildings, and especially all magazines, to have such an apparatus for defending them from lightning ?

A. They

A. They certainly ought, and many, I believe, have.

Q. Does lightning do great mischief in this cold climate of England?

A. Not frequently; yet such a thing sometimes happens, as was the case with St. Bride's church, in London, the steeple of which was damaged by a thunder storm in 1764.

Q. Is not the fire of electricity very different from common fire?

A. It is, and operates in a very different manner. It has been known to melt a sword in the scabbard without injuring the scabbard itself; and to melt money in a man's pocket without burning his cloaths. In a word, it seems to be of such a nature, that it can easily penetrate through porous bodies without affecting them, and spends all its force upon those that are hard and solid.

Q. May not the experiment of drawing lightning from heaven, by means of an electric kite, be attended with danger?

A. It no doubt may, and even actually has. It proved fatal to Abbé Richman, who, in 1753, was killed by a flash of lightning he drew down from the clouds, in an experiment he was making at Pittsburgh.

Q. Has not electricity been applied to some medical purposes?

A. It has, and that too, it is said, with so much success, that it may now be considered as part of the science. We believe, however, that those who administer it, are rather looked upon by the rest of the faculty as so many quacks, as indeed the exhibitors of all new medicines are till their authority is firmly established.

Q. May not some electrical experiments be performed without the help of an electrical machine?

A. Yes, such as shew the attractive and repulsive power of bodies, but not such as produce lightning. Here follows one. Cut two bits of cork into the shape and size of a common pea. With a needle draw a thread through each of the corks, so that they may hang at the ends of the threads with a knot below them. Let the other ends of the threads be inserted in the notch of a small piece of wood, about a foot long, an inch broad, and of the thickness of a common match. Lay the piece of wood over the mouths of two wine glasses a few inches asunder, so that the end of it, in which the threads are, may project over the edge of the higher glass, and the corks may be in contact with one another. Take another wine glass, and having rubbed it heartily with a piece of

of flannel, or the skirt of a woollen coat, hold its mouth to within about an inch of the corks, and you will see them suddenly start and continue a-funder for a considerable time.

Q. How does it appear that electricity has any share in producing earthquakes?

A. This has been already explained in page 22.

Q. You said, that in the opinion of some philosophers, the *Aurora Borealis*, or Northern Lights, are owing to electricity. Who are the philosophers that entertain this opinion?

A. Signior Beccaria, of Turin, was the first that advanced it. He thinks that the *aurora borealis* may be the electric matter performing its circulation in such a state of the atmosphere as renders it visible, or approaching nearer to the earth than usual.

He was followed in the same sentiments by Mr. Canton, our countryman, who says, that the *aurora borealis* may be the flashing of electric fire from positive towards negative clouds,* at a great distance, through the upper part of the atmosphere, where the resistance is least. He supposes, that the *aurora borealis*, which happens at the time

* Clouds are said to be positive when they have too much electricity, and negative when they have too little.

that

that the needle (in the mariner's compass) is disturbed by the heat of the earth, is the electricity of the heated air above; and this, he says, will appear chiefly in the northern regions, as the alteration in the heat of the air in those parts will be the greatest.

This hypothesis, he adds, will not seem improbable, if it be considered, that electricity is now known to be the cause of thunder and lightning; that it has been extracted from the air at the time of an *aurora borealis*; that the inhabitants of the northern countries observe the aurora to be remarkably strong, when a sudden heat happens after severe cold weather; and that the curious in these matters are now acquainted with a substance that will, without friction, both emit and absorb the electric fluid, only by the increase or diminution of its heat: meaning the Tourmalin, a singular kind of stone, the properties of which were about this time discovered.

Q. Is not electricity supposed to be the cause of many other phænomena besides those you have mentioned?

A. Signior Beccaria thinks it is the cause of *water spouts*. To make this the more evident, he first describes the circumstances attending the appearance of these spouts. They are as follow.

They

They generally appear in calm weather. The sea seems to boil, and send up a smoke under them, rising into a hill towards the spout. At the same time, persons who have been near them have heard a rumbling noise. The shape of a water spout is that of a speaking trumpet, the wider end being in the clouds, and the narrower end towards the sea.

The size is various even in the same spout.—The colour is sometimes inclining to white, and sometimes to black. Their position is sometimes perpendicular to the sea, sometimes oblique, and sometimes the spout itself is in the form of a curve. Their continuance is very various, some disappearing as soon as formed, and some continuing a considerable time. One that he had heard of continued a whole hour. But they often vanish, and presently appear again in the same place.

Q. Does not Beccaria likewise suppose, that whirlwinds and hurricanes are owing to electricity?

A. He does, and adds, that what water spouts are at sea, whirlwinds and hurricanes are by land. They have been known to tear up trees, to throw down buildings, make caverns in the earth ; and in all these cases, to scatter earth, stones, bricks, timber, &c. to a great distance in every direction. Great quantities of water have been left, or raised

by

by them, so as to make a kind of deluge ; and they have always been attended with a prodigious rumbling noise.

That these phænomena depend upon electricity, cannot, he says, but appear very probable from the nature of several of them ; but the conjecture is made more probable from the following additional circumstances.

They generally appear in months peculiarly subject to thunder storms, and are commonly preceded, accompanied or followed by lightning, rain, or hail. Whitish or yellowish flashes of light have sometimes been seen moving with prodigious swiftness about them. And, lastly, the manner in which they terminate exactly resembles what might be expected from the prolongation of an electrified cloud towards the sea ; the water and the cloud mutually attracting one another : for they suddenly contract themselves, and disperse almost at once ; the cloud rising, and the water of the sea under it falling to its level.

But the most remarkable circumstance, and the most favourable to the supposition of their depending upon electricity, is, that they have been dispersed by presenting to them sharp-pointed knives or swords. This, at least, is the constant practice of mariners, in many parts of the world where these

water spouts abound; and he was assured, he says, by several of them, that this method has often been attended with success.

Q. I think I have heard it said, that the meteor we usually call a falling star, is an electrical appearance: is it so?

A. It probably is, and the fact, which Signior Beccaria mentions in confirmation of this opinion, is very curious and remarkable.

As he was one time sitting with a friend in the open air, an hour after sun-set, they saw what is called a falling star directing its course towards them, and apparently growing larger and larger, till it disappeared not far from them; when it left their faces, hands, and cloaths, with the earth, and all the neighbouring objects, suddenly illuminated with a diffused and gentle light, attended with no noise at all.

While they were starting up, standing, and looking at one another, surprised at the appearance, a servant came running to them out of a neighbouring garden, and asked them if they had seen nothing; for that he had seen a light shine suddenly in the garden, and especially upon the streams which he was throwing to water it.

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